

XVI.—*On the Muscular Force of Insects.*

By FÉLIX PLATEAU\*.

THE measurement of the strength of invertebrate animals, and especially of Insects, appears never to have been the object of any investigations; and yet, as will be seen hereafter, how much does this strength, compared with the weight of the animal, exceed that of Man and the Mammalia. Here and there only, in the writings of some authors, we find indications which prove that this extraordinary strength has not completely escaped observation. In this respect I shall cite two sentences of Pliny. In the first place, speaking of insects in general, he says, "In his tam parvis atque tam nullis, quæ ratio, quanta vis, quam inextricabilis perfectio!" and again, with regard to the ants, "ac si quis comparet onera corporibus earum, fateatur nullis, portione vires esse majores." Lastly, I find the following passage in one of Sir Walter Scott's novels (*Peveril of the Peak*, chap. xxxv.) :—"Hence the smallest creatures are frequently the strongest. Place a beetle under a tall candlestick, and the insect will move it by its efforts to get out; which is, in point of comparative strength, as if one of us should shake his Majesty's prison of Newgate by similar struggles."

What, relatively to the weight of the animal, is the muscular force in different species of insects? how many grammes, on an average, can one of these species move by traction, or pushing, or during flight? and is this force subject to any law? Such are the various questions that I have sought to solve by experiments, which are certainly very simple, but the results of which cannot but be interesting when compared with those furnished by researches of the same kind made upon the human subject and the horse.

Before proceeding further, I will sum up in a few words the processes which I have employed. I ascertained the force of traction by making an insect draw horizontally a thread passing over a pulley and having at its other extremity a pan containing weights, which are increased up to the maximum that the insect can move.

Pushing is effected by burrowing insects on one of the extremities of a horizontal lever moving upon a vertical axis, the other extremity of which raises weights by means of a thread passing over a pulley as in the preceding case.

Lastly, the force developed in flight is measured by attaching to the two posterior legs of the insect a small mass of wax,

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which is at first too large for it to move, and is then diminished until the insect can barely support it in the air by the movement of its wings.

In these three kinds of experiments the muscular force of a species is represented by the relation between the mean maximum weight moved individually by a certain number of insects of the species in question and the mean weight of the insects.

The deductions which I draw from the results taken in their totality are as follows:—

1. *Leaving flight out of consideration, insects have, relatively to their weight, an enormous strength in comparison with Vertebrata.* Thus, from experiments made with draught-horses, these animals, the average weight of which is about 600 kilogrammes, can only exert for a few moments a force of traction equivalent to 400 kilogrammes, that is to say, two-thirds of their own weight; but I have found that the common Cockchafer (*Melolontha vulgaris*) and *Donacia nymphaeæ* exert a force equal respectively to fourteen times and forty-two times their own weight.

The pushing led to analogous results; but, in general, the weights raised by insects during flight are much less, which might be expected, as these little animals have never to transport considerable burdens through the air, as is done especially by the Rapacious Birds\*.

2. The weight of insects and the ratios representing their muscular force are connected by what appears to be a general law, at least according to the numerous experiments that I have made. The following is the law, which is clearly manifested both in the case of flight, and in those of traction and pushing:—*If in the same group (family or tribe) of insects we examine two species which differ considerably in weight, the smallest and lightest will exhibit the greatest force; in other words, in the same group the force, always measured by the relation of the weight moved to that of the animal, varies from species to species in an inverse ratio to the latter weight.*

In connexion with this I will give a few examples taken from the tables of my memoir. These tables contain for each species, besides the mean ratios expressing the force of that species, the maximum of the isolated ratios furnished by the different individuals experimented on; and the law is manifested therein, not only in the mean ratios, but also in the individual maximum just mentioned.

[\* M. Plateau seems here to have forgotten the Sand-Wasps, many of which carry caterpillars of comparatively large size to their burrows.—W. S. D.]

	Mean weights of species.	Mean weights moved.	Mean ratios.	Individual maximum ratios.
TRACTION.				
Melolontha vulgaris . . . .	0·940 gr.	13·456 gr.	14·3	23·2
Anomala Frischii . . . . .	0·153 „	3·721 „	24·3	66·4
PUSHING.				
Oryctes nasicornis . . . . .	2·117 gr.	6·702 gr.	3·2	4·2
Geotrupes stercorarius ..	0·492 „	8·298 „	16·9	28·4
Onthophagus nuchicornis	0·056 „	4·457 „	79·6	92·9
FLIGHT.				
Bombus terrestris . . . . .	0·214 gr.	0·134 gr.	0·63	0·87
Apis mellifica . . . . .	0·083 „	0·065 „	0·78	1·00

The comparative examination of the locomotive limbs in most of the species experimented on has shown me that the volume of the muscles of these organs appears in general to decrease more rapidly in proportion than the weight; it seems, therefore, that we must attribute the greater strength of the small species to a greater muscular activity or energy. The reason of this difference in favour of insects of small size is, perhaps, beside all anatomical or physiological considerations: thus the hardness of the ground in the case of burrowing insects, the objects which impede their progress in simple locomotion, and the inertia of the air in flight, form resistances to be overcome which are the same for the large and small species; now to avoid giving a useless excess of force to the former, or fatally depriving the latter, nature must endow the smaller species with a greater muscular energy. Considerations of the same kind may, in my opinion, be applied to the first of the principal facts deduced from my investigations, namely the enormous strength of insects in comparison with vertebrate animals; for if the reasoning appears just when applied to two insects of different sizes and weights, it must be admitted, I think, with still more reason, when an insect is compared with a mammal.

XVII.—*Descriptions of several Species of Trichopterygidæ found by Dr. H. Schaum in various parts of North America and Brazil.* By the Rev. A. MATTHEWS.

[Plate V.]

THE insects described in the following pages were collected in various parts of North America and in Brazil by Dr. Schaum, of Berlin, to whose kindness I am indebted both for the privilege of thus introducing them to the notice of entomologists, and